18 PRTS

10/538644

JC09 Rec'd PCT/PTO 10 JUN 2005

HYDRAULIC OR PNEUMATIC MACHINE WITH TILTING BLADES

TECHNICAL FIELD OF THE INVENTION

The invention pertains to a hydraulic or pneumatic machine with tilting blades in simple and solid construction which can be built in various constructional variants, meant to run with high efficiency as an engine fed by a fluid stream, pressure stream or pressure gases resulted from fuel combustion or as a pump or compressor with a broad range of industrial applications.

BACKGROUND OF THE INVENTION

There is a large variety of hydraulic or pneumatic machines having the rotor equipped with swinging or tilting blades round a fixed shaft on the rotor parallel or perpendicularly to its rotation axis driven by its own weight, by the centrifugal force or by its own driving mechanisms. During a full rotor rotation, the blades are putting up the maximum resistance to the motion to the fluid stream sense taking over part of its energy and the minimum resistance to the motion to the opposite sense of the fluid stream.

Such machines have the disadvantage of a sturdy, sophisticated, low efficiency construction.

There are also hydraulic or pneumatic machines - motors or pumps - using pressure working fluids, being equipped either with gliding blades in the rotor or hinged blades on it, having the disadvantage of very narrow application ranges from the point of view of the working parameters and of a very elaborate execution in terms of accuracy, a rapid wearing of the active elements, very high stresses in the rotors bearings and an outlet couple with variable value.

The technical issue solved by this invention consists in the execution of a hydraulic or pneumatic machine having rotors provided with tilting blades which assures the taking over of the moving energy of the whole amount of fluid throughout and can be integrated - alone or in a battery of machines - in units to capture the energy of a moving fluid for a very wide range of fluid flow rates.

DISCLOSURE OF INVENTION

The hydraulic or pneumatic machine with tilting blades according to the invention permits to achieve the goal as it can be built in various constructional variants, running either as a hydraulic or pneumatic motor on fluid stream with one stage, made up of a cylindrical casing with flat or shaped lids and radial inlet and outlet nozzles for the working fluid, diametrically opposed, arranged to the fluid flow direction, two coaxial disc like rotors, having the diameters close to that of the casing, found under rotation movement in the opposite sense to one another due to some shaped tilting blades - of a rectangular shape, or, eventually, having two opposite curve sides - radially arranged or in an angle to the radius, hinged onto the neighbouring front surfaces of the two rotors, towards their periphery, the angle formed in the hinge, between the rotor surface and that of the associated blade, having the vertex arranged to the moving sense of each rotor and the values varying during the rotor rotation - between 0° - when the blade is in passive position, eventually located in a properly shaped seat on the face of the respective rotor - and a maximum angle of 90° eventually - when the blade is in active position, the position of the tilting blades on each rotor being driven, during the rotor rotation, by a driving mechanism of its own, with cams, known in themselves; a cylindrical drum located between the front faces provided with the tilting blades of the rotors, coaxial with them, fixed onto the machine casing by a shaped deflector and a rib found within the symmetry plane of the inlet - outlet nozzle, so that inside the machine are formed two channels

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of the channel, the instantaneous motive force arising in each compartment of the respective zone being proportional to the depth difference of the channel, in that moment, near the two tilting blades delimiting each compartment and the pressure of the respective compartment; a pump or a compressor, if angle vertex between the blade and the face of the rotor is orientated to the opposite sense of the rotor moving sense, the shaft of which is driven by an outside couple, the fluid being sucked in this case in the final zone of the channel and compressed in its initial zone; in various constructive variants either on the faces of a cylindrical ring may be provided with several channels, independent or coupled between them, in series - through some intermediate, shaped channels - or in parallel, making different circuits accordingly, coupled or independent ones having the same functional role or various roles, the driving mechanisms of the tilting blades being orientated according to the position of the channel or of the respective circuit or in case the machine is staged, the fluid circuits from various stages being coupled by means of some connecting pipes or by some spacer rings with the corresponding inner channels located between the cylindrical rings of each stage, in a variant, in order to diminish the axial forces resulting in the bearings of the rotors shafts the machine having at all the stages only rotors with tilting blades on both faces whereas in another variant it has a single outlet shaft locating one or several similar rotors, with tilting blades on one or both front faces, the machine being able to run as a pneumatic motor - fed on pressure gas coming from an outside tank or from the fuel combustion in a combustion room equipped with feeding devices, for the formation of the fuel mixture and its ignition, known in themselves-ensuring expansion of the working gas in one channel or a prolonged expansion in several coupled channels, or as a hydraulic motor fed on a pressure liquid, or as a pump or compressor, or with both motive and independent pumping circuits. Against the known solutions, the hydraulic or pneumatic machine, according to the invention, has several advantages, such as:

- the possibility to make highly efficient motors on fluid flow, having reduced size rotors and low value starting couple due to the fluid circulation through the machine in symmetrically arranged channels on one or several stages and to the flow concentrations due to the convergent shape of the respective channel whereas the energy conversion system is coupled to the motor shaft - an electric generator eventually - located outside the fluid flow;

- the possibility to build sturdy machines with a low number of parts under rotation and a very low number or no number of parts at all under translator motion, with low values of forces and relative velocities in the contact points between the parts;

- the possibility to build motors with quasiconstant couple at the outlet shafts;

- the possibility to build balanced machines with axial and radial forces having minimum values in the rotors bearings;

- the possibility of making pneumatic machines, engines or compressors where the prolonged expansion or fluid compression respectively is achieved in circuits consisting of one or several channels coupled in series or in parallel, the small pressure differences between the compartments formed along the channels, between the successive blades of each rotor, resulting in low stresses in the tilting blades and in the bearings thereof as well as in low pressure loss values between the successive compartments or towards the outside;

- the possibility of achieving a large constructional variety of units to make best use of the kinetic energy of a fluid flow, with constant or variable direction continuous or intermittent flow, floating or fixed units, in unsophisticated, solid construction and with small overall dimensions;

- the possibility of making a wide constructional variety of hydraulic or pneumatic machines for static pressure fluids, with one or several circuits having the same functional role - motor or pump - or different roles, with the same fluid in all circuits or with different fluids;

- the possibility to make a thermal machine with a low number of parts or no parts at all under translator movement, with high mechanical efficiency, having the combustion room incorporated inside or outside, with the compression circuits of the air or the fuel mixture and burned gases expansion circuits respectively located in the same or different machines.

Herein under are several examples of the way the invention is materialised making also reference to Figs. 1 ÷ 123.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 - Cross section in vertical plane of a hydraulic or pneumatic machine, according to the invention, in one constructional variant;

Fig. 2 - Cross section in horizontal plane, to line **I** - **I** of Fig. 1;

Fig. 3 - Cross section of the upper rotor, in a constructional variant;

Fig. 4 - Partial top view of the upper rotor **B** shown in Fig. 3;

Fig. 5 - Cross section of the lower rotor **C** in a constructional variant;

Fig. 6 - Partial top view of the lower rotor **C** shown in Fig. 5;

Fig. 7, 8 - Top view of tilting blade **12**, in various constructional variants;

Fig. 9 ÷ 11 - Cross section to line **II** - **II** shown in Fig. 8, 9 of the tilting blade 12 in various constructional variants;

Fig. 12 - Cross section to line **III** - **III** shown in Fig. 6, of a shaped channel **b**;

Fig. 13 ÷ 16 - Partial view of a front face of a rotor (**B**, **C**) in various constructional variants;

Fig. 17 - Cross section to line **IV** - **IV** of Fig. 16;

Fig. 18 - Partial cross section in vertical plane of a hydraulic or pneumatic machine according to the invention, in a constructional variant;

Fig. 19 - Partial view of a front face of a rotor (**B**, **C**) in another constructional variant;

Fig. 20 - Cross section to line **V** - **V** shown in Fig. 19;

Fig. 21 - Partial view from the direction **VI** of the tilting blades driving mechanisms shown in Fig. 1;

Fig. 22 - Partial section to line **VII** - **VII** shown in Fig. 21;

Fig. 23 - Partial section to line **VIII** - **VIII** shown in Fig. 21;

Fig. 24 - Partial cross section in vertical plane of a machine according to the invention, with a constructional variant of the tilting blade driving mechanism;

Fig. 25, 26 - Partial view from direction **IX** with the schematic diagram of the moving sense of the blade and tappet in various assembling variants;

Fig. 27 - Partial cross section in vertical plane of a machine according to the invention, in another constructional variant of the tilting blade driving mechanism;

Fig. 28, 29 - Partial cross section to line **X** - **X** with the schematic illustration of the moving sense of the tilting blade and the tappet in various assembling variants;

Fig. 30 - Detail of the guide faces of the cam no. 34;

Fig. 31 - Detail of the guide faces of the cam no. 35;

Fig. 32 ÷ 35 - The schematic diagram of the lever driving mechanism shown in Fig. 21, in various constructional variant;

Fig. 36 - Partial section, rotated in horizontal plane, to line **XI** - **XI** shown in Figs. 33, 35 and 41;

Fig. 37 - Assembling detail of the tappet at the driving mechanism shown in Figs. 25, 26, in a constructional variant;

Fig. 38 - Assembling detail of the tappet for the driving mechanism shown in Figs. 28, 29, in a constructional variant;

Fig. 39, 40 - Partial cross section in vertical plane of a machine according to the invention, in other constructional variants of the tilting blade driving mechanism;

Fig. 41, 42 - Partial view from direction XII of the driving mechanism of the blades shown in Fig. 40 in various constructional variants;

Fig. 43 - Partial cross section in vertical plane of a machine according to the invention, in another constructional variant of the tilting blade driving mechanism;

Fig. 44, 45 - Section to line XIII - XIII shown in Fig. 43, in various constructional variants;

Fig. 46 - Section to line XIV - XIV shown in Fig. 43;

Fig. 47 - Developed schematic diagram of the partial evolution of the blade on each rotor during its full rotation;

Fig. 48 - Front view of deflector 46 in a constructional variant;

Fig. 49 - Partial cross section in horizontal plane to line I - I shown in Fig. 1 in a constructional variant;

Fig. 50 - Partial cross section in vertical plane to line XV - XV shown in Fig. 49;

Fig. 51 - Schematic diagram of the coupling of opposite outlet shafts of the machine to a single outside shaft;

Fig. 52 - Schematic diagram of a machine according to the invention with coaxial outlet shafts coupled to a single outside shaft;

Fig. 53 - Partial schematic diagram of an additional bearing located on the lower lid, a variant to Fig. 52;

Fig. 54 - Schematic diagram of a machine according to the invention with coaxial outlet shafts coupled to a single outside shaft, in a constructional variant;

Fig. 55 - Partial, schematic diagram of an additional bearing located on the upper lid, a variant to Fig. 54;

Fig. 56 - Schematic diagram of a machine according to the invention in one assembling variant;

Fig. 57, 58 - Partial cross section in vertical plane of a hydraulic or pneumatic machine according to the invention with channels on two stages, in various constructional variants;

Fig. 59 - Partial cross section, in vertical plane, of a hydraulic or pneumatic machine according to the invention with channels on three stages;

Fig. 60 - Cross section to line XVI - XVI shown in Fig. 59;

Fig. 61 - Cross section to line XVII - XVII shown in Fig. 60;

Fig. 62, 63 - View from direction XVIII shown in Fig. 60 in various constructional variants;

Fig. 64 - Partial cross section of a E type rotor;

Fig. 65 ÷ 68 - Partial cross section of a F type rotor in various constructional variants;

Fig. 69 - Section to line XIX -XIX shown in Figs. 65 and 73;

Fig. 70 - Section to line XX - XX shown in Figs. 66 and 74;

Fig. 71 - Section to line XXI - XXI shown in Figs. 67 and 75;

Fig. 72 - Section to line XXII - XXII shown in Figs. 68 and 76;

Fig. 73 ÷ 76 - Partial cross section of a G type rotor in various constructional variants;

Fig. 77 - Detail of "hinge" type tilting blade;

Fig. 78 - Detail of "hinge" type tilting blade matching that shown in Fig. 77;

Fig. 79 ÷ 81 - Detail of the driving mechanism of the "hinge" type coaxial tilting blades in various constructional variants;

Fig. 82, 83 - Detail of the synchronisation mechanism of the tilting blades driving at various stages, arranged on the rotor outside, in various constructional variants;

Fig. 84, 85 - Detail of the synchronisation mechanism of the tilting blades driving at various stages, arranged inside the rotors, in various constructional variants;

Fig. 86 ÷ 88 - Schematic cross section on 90° - 270° centerline of a multistage machine with an even number of stages, in various constructional variants;

Fig. 89 ÷ 91 - Schematic cross section on 90° - 270° centerline of a multistage machine with an uneven number of stages, in various constructional variants;

Fig. 92 - Schematic front view of a cylindrical ring 92 according to a constructional variant, with an open a channel;

Fig. 93 - Cross section to line **XXIII - XXIII** shown in Fig. 92;

Fig. 94 - Developed schematic diagram of the channel a profile in the cylindrical ring 92 according to the constructional variant with open channel;

Fig. 95 - Developed schematic diagram of the channel a profile in the cylindrical ring 92 according to the constructional variant with closed channel;

Fig. 96 - Developed schematic diagram of the channel a profile in the cylindrical ring 92 according to the constructional variant with overlapped channels;

Fig. 97 - Detail of fluid inlet according to a constructional variant;

Fig. 98 - Cross section to line **XXIV - XXIV** shown in Fig. 97;

Fig. 99 - Detail of fluid inlet according to other constructional variant;

Fig. 100 - Cross section to line **XXV - XXV** shown in Fig. 99;

Fig. 101 - Detail of fluid inlet according to other constructional variant;

Fig. 102 - Cross section to line **XXVI - XXVI** shown in Fig. 101;

Fig. 103 - Schematic diagram of the tilting blade 12 position in the zone having decreasing depth b of channel a according to two functional variants;

Fig. 104 - Detail of fluid outlet according to a constructional variant;

Fig. 105 - Cross section to line **XXVII - XXVII** shown in Fig. 104;

Fig. 106 - Detail of fluid outlet according to other constructional variant;

Fig. 107 - Cross section to line **XXVIII - XXVIII** shown in Fig. 106;

Fig. 108 - Schematic diagram of fluid inlet, with incorporated combustion chamber, according to a constructional variant;

Fig. 109 - Schematic diagram of fluid inlet connection to the outside combustion chamber, according to a constructional variant;

Fig. 110 - Schematic front view of a cylindrical ring 92 with two independent channels a''_1, a''_2 on the same front face;

Fig. 111 - Schematic diagram of a cylindrical ring 92 with two channels a''_1, a''_2 coupled, in parallel on each face;

Fig. 112 - Schematic diagram of a cylindrical ring 92 with two channels a''_1, a''_2 coupled in series according to two functional variants - motor or compressor (pump);

Fig. 113 - Schematic diagram of a cylindrical ring **92** with the combustion chamber incorporated between two channels $\underline{a''}_1$, $\underline{a''}_2$ connected in series;

Fig. 114 - Schematic section in vertical plane, of a hydraulic or pneumatic machine having channels with variable depth, according to a constructional variant;

Fig. 115 ÷ 117 - Schematic section in vertical plane of a hydraulic or pneumatic machine, having channels with variable depth, with two stages, with axially balanced rotor, in various constructional variants;

Fig. 118 ÷ 120 - Schematic section in vertical plane of a hydraulic or pneumatic machine, having channels with variable depth, with a single shaft, in various constructional variants;

Fig. 121,122 - Schematic section in vertical plane of a hydraulic or pneumatic machine, having channels with variable depth, with two stages, with axially balanced rotors, one outlet shaft, according to various constructional variants;

Fig. 123 - Schematic section in vertical plane of a hydraulic or pneumatic machine, having channels with variable depth, balanced axial rotors, with the combustion chamber incorporated in the cylindrical ring **92**, according to a constructional variant.

BEST MODE FOR CARYING OUT

EXAMPLE 1

The hydraulic or pneumatic machine with vertical shaft made according to the invention consists of a fixed stator **A**, two disk like rotors, an upper one **B** and a lower one **C**, spaced from one another by a drum **D** connected onto stator **A**, all elements being in line, the parallel front faces of the two rotors being equipped with tilting blades which, due to some driving mechanisms of their own, can take against the rotor either a passive position - the blade in the front plane of the rotor, or an active position - the blade inclined by an $\alpha \leq 90°$ angle against the front face of said rotor. Inside the machine, two symmetrical, semicircular channels <u>a</u> are formed and due to the manner the driving mechanisms are arranged within the machine, the blades of one rotor are in active position, obstructing the passage of respective channel while the blades of the other rotor are in passive position, so that the circulating fluid along the two channels <u>a</u> flowing to the same sense, actuates the blades found simultaneously in active position on the two rotors **B** and **C** and dictates their movement to opposite direction from one another, each rotor conveying the energy taken from circulating fluid to its shaft.

The stator **A** is made up of a cylindrical shell **1** locating on a radial direction, diametrically opposed a fluid inlet **2** and an outlet **3**, a detachable upper lid **4** and a lower lid **5** in interdependence with the shell **1**. The inlet **2** and outlet **3** are eventually in the form of convergent or divergent nozzle respectively. The height of the passage section of inlet **2** and outlet **3** nozzles at shell entrance, shall not exceed the distance between the front faces of the rotors **B** and **C**.

The upper **B** and lower **C** rotors are each made up of a flat ring plane **6** with identical, equally spaced, shaped grooves <u>b</u>, on the front surface delimiting channel <u>a</u>, secured to a frame **7** forming one part to a disc **8** and **9** respectively, provided with a hub **10**, **11**.

Some tilting blades **12** are hinged on each flat plane **6**, in the shaped grooves <u>b</u>.

Each tilting blade **12** consists either of a rectangular or a distorted rectangular panel <u>c</u> with two opposite sides <u>d</u> and <u>e</u>, curves-arches of ellipse, as the blade in active position is perpendicular onto the front surface of

the rotor or makes together with it an $\alpha < 90°$ angle, having fastened on one of its straight sides a cylindrical hub f provided with a central orifice g.

The profile of the curve sides d and e is selected in such a manner as, when the blade is in active position, inclined by an angle α against the front face of rotor, all the points of the respective side be on the same cylindrical face.

The panel c has an upper flat face h, tangential to the hub face f and a lower flat face i, representing the active face of the blade on which, when in operation, the fluid exerts its pressure.

In other constructional variants, in view of making the blade a solid of equal strength and of improving the hydraulic efficiency of the machine, the lower face of panel c can be shaped to a curve j known in itself, or can be also provided with stiffening ribs k.

The groove b has a semicylindrical face l connected to the front face of the ring plane 6 by means of a flat plane m and a surface n shaped to the blade 12 shape. Each groove is delimited in the case of a rectangular blade, at the outward end, by a flat surface o provided with an orifice p and at the other end, a flat surface q with an orifice r. In the case of the blade with curve sides, d and e, the groove is delimited at the both ends by some curve surfaces s and t respectively, with adequate profile.

The two orifices, p and r, are in line and serve to fix some radial or axial - radial bearings 13 and 14, known in themselves. Blade fastening into the bearings 13 and 14 of the rotor is achieved by a shaft 15 fixed in the orifice g of the blade hub by known means, not shown in the drawing, a shaft also used for blade actuation.

Each blade is directed together with its hub to the moving direction of the rotor it is mounted on, while the rotation axis of the blade, passing through the bearings 13 and 14 is either on the radial direction or it makes with the tangent to the inner circular outline of the plane 6, run to the piercing point of respective axis a $\beta < 90°$ angle, with the vertex facing the rotor moving direction.

In a constructional variant, in the absence of plane 6, the rotor consists of an external stiffening ring 16 provided with orifices p, fixed on the frame 7 which in provided with orifices r, by means of rods 17, known in themselves, radial oriented, also meant as position limiters for the blades 12 found in passive position being shaped to the blade profile to this effect.

In case of large size rotors, in order to take over the axial loads due to their own weight, on the ring 16 of the rotor, between the bearings 13 of the blades 12, some equally spaced bolts 18 are fastened for the free rotation on them of same rollers 19 with spherical surface. The rollers of upper rotor B installed toward the outer side of ring 16 are guided between a flat ring surface u of a cylindrical gap v provided at the upper side of the shell 1 and the lid surface 4, while the guide rollers of the lower rotor C, installed toward the inner side of the ring 16 are supported on the lower lid 5 of the stator A.

In another constructional variant blade 12 is bracketed, resting only against bearing 14 on the ring 7 and having the outer end free. Position limiters 20 are provided on ring 7 for the passive position of each blade 12.

Each tilting blade 12 is provided with a driving mechanism, which can be built in several constructional variants, of elements known in themselves, the driving element of the blade being fastened on the end facing the inner side of the shaft 15.

According to a first variant, the driving element is a lever 21, the free end of which being provided with a fixed axle 22 on which a roller 23 moves freely. All the rollers 23 of the upper rotor B are guided between the upper guiding front surface w and the lower one x - of a fixed circular guide cam 24, whereas those of the lower rotor C between the front upper y and lower z guide surfaces of a fixed, circular cam 25. The two cams 24 and

25 have the same profile and are symmetrically arranged against the symmetry plane passing through the axis of inlet - outlet openings.

In another constructional variant, the driving element is a pinion 26 geared on a tappet with rack 27 provided at the end with a fixed shaft 22 with roller 23, guided by cams 24 or 25 respectively, the tappet being able to make a translation movement in a vertical guide a' or, according to another variant b', with a protection casing 28 of mechanism, fixed on the rotor, the position of the vertical guide against the pinion 26 determines both its rotation sense and therefore that of blade 12 during the translation movement of tappet, and the profile of cams 24 and 25.

According to another constructional variant, the driving element is a cone pinion 29 geared with a cone gear with vertical axis 30 in interdependence and in line with a cylindrical gear 31 provided with a spindle 32 which can freely rotate in the bearing c' of a protection casing 33 of the mechanism, fastened onto the rotor. The gear 31 engages with the rack tappet 27 provided with a fixed shaft 22 having the roller 23, the tappet being capable to execute a translation movement in a horizontal guide d' or, according to another variant e', of casing 33, the guide position to gear 31 determines its sense of rotation and therefore of the blade 12 during the tappet translation movement. All the rollers 23 of the upper rotor B are guided between some outer f' and inner g' radial, guiding surfaces of a fixed radial cam 34, while those of the lower rotor C, between the outer h' and inner i' guiding surfaces of a fixed radial cam 35. The two cams 34 and 35 have similar profiles and are symmetrically arranged against the symmetry plane running through the axis of inlet and outlet openings.

According to these variants, the two guide surfaces of each cam 24, 25, 34, 35 secure the closure of the cinematic chain of the blade driving mechanism.

According to other constructional variants, the cams have one guide surface each, closing of the cinematic couple of the blade driving mechanism being achieved either by the direct action of fluid pressure over the active surface of the blade, adequately shaped, or by additional elements, known in themselves, assuring the permanent contact of the roller with the cam surface.

Thus the roller 23 of the lever drive mechanism of the blade on the upper rotor B and lower rotor C respectively, is maintained under contact to the surface w of came 24 and surface z of cam 25 respectively, either due to a counterweight 36 installed on an extension j' of lever 21 in the case of upper rotor B or on lever arm 21, in the case of lower rotor C, or due to a spring 37, known in itself, installed in line with the tilting blade axis and twisted to the right sense so as to press the roller 23 on the cam surface, having one end fixed in an orifice k' provided in frame 7 and the other end resting in an orifice l' of lever 21. Under this variant, the blade tilting in active position during a full rotor rotation is secured by the profile of the contact surfaces w and z respectively, while resetting and keeping of the blade in passive position on rotor are secured by the said elements 36 or 37. The aperture angle of the blade in active position is limited by means of a stopper 38, known in itself, fastened onto the inner face of the rotor frame 7, having the role to limit the rotation of lever 21 arm j'.

In another variant, the roller 23 of the lever drive mechanism of the blade on upper B and lower C rotors respectively, is kept into contact with the cam 24 surface x and y of cam 25, either by installing a counterweight 36 on lever arm 21 for the upper rotor B, respectively on the extension j' of lever 21 for lower rotor C, or by a spring 37 twisted to the right sense. According to this variant, blade tilting in active position is assured by element 36 or 37 while resetting and keeping of the blade in passive position are assured by the profile of the contact surface x and y, respectively.

In other constructional variants, when blades 12 are driven by vertical or horizontal tappets, the permanent contact between the rollers 23 and the guide surfaces x and y of the cams 24 and 25 and g' and i' of

the cams 34 and 35 respectively is maintained by means of compressed springs 39 installed in guides a' or b' and d' or e' respectively, under tappets ends.

The cams 24, 25 and 34, 35 respectively are fixed inside the drum **D** which is in line with the two rotors **B** and **C**, by means of ribs **40**, known in themselves.

In another constructional variant, the cams 24, having the guide surface w and 25 having the guide surface z are located on the upper lid 4 and lower lid 5 respectively.

In this case casings 28 are installed with the guides a' or b' oriented to the rotors disks 8 and 9 respectively, provided with orifices m', corresponding to the associated guides for passing the tappets 27, their compression on the guide surfaces of cams being achieved by the springs 39 installed under compression in the tappets guides.

In case of tappets drive, the aperture angle of the blade is limited by the limitation of tappet stroke, chosing the suitable distance between its end and the guide bottom.

In another constructional variant, the tilting blades 12 of upper rotor B are guided by a front cam 41 with a guide surface n', while those of the lower rotor C by a front cam 42 with a guide surface o', both of them fixed in the fluid flowing channel a on the outer face of drum D, at its ends. The panel c of each blade is provided with a gap p' each, corresponding to the modified profile of the fluid flowing a channel, due to the existence of the two cams. On the surface h of the panel of each tilting blade, in the contact zone with the cam's guide surface, a skid 43 is fixed by known means with an r' end the shape of which suits the contact with the cam surface, eventually provided with a contact roller, known in itself, not shown in the drawing, located in gap p'.

The driving mechanism of each blade consists of lever 21 without roller 23, fixed on shaft 15, driven either by counterweight 36 or by spring 37, as previously described, in order to assure blade lifting in active position, its resetting and keeping in passive position being assured by cams profile 41 and 42.

In another constructional variant, the tilting blade 12 can either rotate freely on shaft 15 fixed on the rotor, in orifices p and r, or it is fixed on shaft 15 installed in bearings 13 and 14, the driving mechanism of the blade consisting of a twisting spring 44, known in itself, located in an orifice s' in line with orifice g, located at the end of the blade's hub f, one of the spring end being fixed in a gap t' existing in the wall of orifice s', while the other is fixed in the orifice k' of the rotor frame 7, so as the spring should be stressed in order to assure, during the rotor movement, the permanent contact between the r' end of skid 43 and the guide surface of the associated cam and consequently blade 12 lifting from passive position to active position on rotor, when the cam profile allows it.

In these variants, angle α is limited either by the position of cams 41, 42 against the front surface of respective rotor, for $\alpha < 90°$, or by the surface m of groove b for $\alpha = 90°$.

During a complete rotor rotation, each blade makes a rotation movement, being at the same time capable to take, due to its own driving mechanism, an active position, when the upper face h of blade is inclined by an angle $\alpha \leq 90°$ against the rotor front face, or a passive position when the upper face h of blade is on the rotor front surface plane, being eventually located in the shaped groove b, or a transition phase from one position to other.

The angles described by a blade in one of the specific positions during a complete rotation of the rotor are marked by γ :

γ_1 - the angle described during the transition phase of the blade from passive to active position;

γ_2 - the angle described by the blade in active position;

γ_3 - the angle described by the blade in the transition phase from active to passive position;

γ_4 - the angle described by the blade in passive position; on condition that $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 = 360°$.

The size of angle α as well as the length of time for maintaining the blade **12** in one of the said positions, during a full rotor rotation, expressed by the value of angles γ are determined by the cam profile of the blade driving mechanism. The profile identity of the two cams **24**, **25** and **34**, **35** or **41**, **42** respectively determines equal values for the pairs of angles γ specific to the two rotors, **B** and **C**.

Cams are fixed so as their guide surfaces should assure the symmetrical plane arrangement of angles $\gamma_1 + \gamma_4$ specific to a rotor, against those specific to the other rotor, the symmetry plane running through the axis of stator **A** inlet - outlet openings.

The drum **D** consisting of a central body **45** with a cylindrical outer face having a deflector **46** and a rib **47**, dyametrically opposed, provided with strengthening plates **48** and **49**, is connected to the stator **A** of the machine by means of spacers **50** and some fastening elements like bolts, nuts, known in themselves, not shown on the drawing, so that deflector **46** and rib **47** be in the mentioned symmetry plane.

The deflector **46** has symmetrical lateral faces **u'** making a sharp angle between them, connected to the outer face of body **45** along its full height.

Blade **12** tilting, in active position, due to its own driving mechanism, can start only after the blade, in passive position on the rotor under rotation movement, outdistanced, with its entire outline, the projection of lateral surface **u'** of deflector **46** on the front surface of the associated rotor, while the return to passive position ends before the blade reaches near the rib **47**. According to one constructional variant, deflector **46** is provided with gaps **v'**, having a curved face, known in itself, permitting either the earlier start of blade tilting, in active position, or deflector extension onto the angular zone γ_1.

Two symmetrical, semicircular channels are thus formed inside the machine, each channel having a rectangular passing section, defined by the front surfaces of the two rotors **B** and **C**, under a rotation movement in opposite direction to one another, the stationary inner face of stator **A** and the outer face of drum **D**.

In order to decrease hydraulic losses, the distance between the front surfaces of the two rotors as well as the diameters of shell **1** surfaces and of drum **D** body **45**, are chosen function of blade **12** dimensions so as to secure minimum clearance from construction viewpoint between the walls of the machine semicircular channel and the edges of the blades, in active position, in the respective channel.

According to a constructional variant, when the blade does not reach the rotor outer edge, in order to reduce the clearance between the outer edge of the blade in active position on rotor and the cylindrical face of the casing **A**, a cylindrical segment **51** is fixed on stator, in each channel, between the front faces of the two rotors **B** and **C**, within the zone covered by angle γ_2.

The two channels **a** directly connected to the inlet and outlet openings, allow separation of machine incoming fluid into two equal streams flowing to the same direction.

By their profile and arrangement, the cams pairs assure blades **12** tilting, in active working position and the return to passive position of each rotor **B** and **C**, in one of the two channels **a**, so that, in each channel the blades of one rotor should be in active position, obstructing its section, while the blades of the other rotor should be in passive position.

The fluid working pressure in each channel exerted on the inner face covered by angle α, of tilting blades **12** of one rotor, when the blades are in active position in respective channel, determines the rotor

movement to the fluid flow direction and the occurrence of an engine couple at its shaft. Due to the fluid flowing to the same direction and to the symmetrical arrangement of the blades in active position on the two rotors, in the two machine channels, rotors **B** and **C** will move to opposite directions from one another, generating equal driving torque.

The number of tilting blades **12** on each rotor is selected in such a manner that between the fluid inlet and outlet openings should, at any time, be at least one blade in active position to obturate channel a, so as not to allow direct fluid circulation between the two machine openings.

Each rotor **B** and **C** by its **10** and **11** hub respectively, is fastened onto a shaft **52** and **53** respectively, through known means - wedges, grooves, etc. - not shown on drawings. The two in line shafts are supported against casing **A** by bearings **54** provided with sealing devices, all elements being known, in orifice w' on the upper lid **4** and orifice x' on the lower lid **5**. The shaft ends rotating to opposite direction from one another get out of the machine on each side of it and can be coupled to a power consumer each, by means of known couplings, not shown on drawing.

According to a constructional variant, the machine has one outer shaft **55** parallel to the in line shafts **52** and **53** of rotors **B** and **C**, supported against an external bearing **56** connected on casing **A** by means of a support **57**, all elements being known in themselves.

On rotor **B** shaft **52** and rotor **C** shaft **53** is installed one cone gear **58** and **59** respectively, in a mirror like arrangement, each one being engaged with a cone gear **60** connected onto the end of an intermediate shaft **61** supported in a bearing **62** on the upper lid **4** and the lower lid **5** of casing **A**, by means of a support **63**.

The shafts **61**, rotating to the same direction, drive by means of cone pinions **64** on the other end of the shafts some cone gears **65** on shaft **55**, all elements being known in themselves.

In another constructional variant, the two in line shafts of the machine get out on one side, through one of the machine lids. To this effect, in case it gets out through the upper lid **4**, the lower rotor **C** is mounted by its hub **11** onto a central shaft **66** whereas the upper rotor **B** is mounted by its hub **10** onto a tubular shaft **67** having a central channel y'. The tubular shaft **67** gets out through the central orifice of the upper lid **4**, resting on it by means of a radial - axial bearing **68** also provided with a sealing device, all elements being known in themselves. The central shaft **66** rests on a radial - axial bearing **69**, also provided with a sealing device, mounted in the central channel y' of a tubular shaft **67**, according to one variant, it can additionally rest on a bearing **70** provided on the lower lid **5**. In case the shafts get out through the lower lid **5**, the upper rotor **B** is mounted on the central shaft **66** while the lower rotor **C** on the tubular shaft **67**, its bearing **68** being mounted in orifice x' of the machine lower lid **5**, the additional bearing **70** being eventually provided on lid **4**.

On the external ends of shafts **66** and **67** are fixed the cone gear wheels **59** and **58** respectively, which rotate to opposite directions from one another and simultaneously engaged with a con pinion **71** on a machine driving shaft **72**, determine its movement to one direction, the motor power at outlet shaft summing up the developed powers of the two rotors. The outlet shaft rests onto the lower lid **5**, by means of a bearing **73** provided with a support **74**, all elements being known in themselves.

In another constructional variant, the two in line shafts **66** and **67** represent the inlet shafts of a planetary reducer **75**, known in itself, whose outlet shaft is coupled to a power consumer.

EXAMPLE 2

The hydraulic or pneumatic machine with vertical shaft, with multistage channels, made according to the invention, allows the circulation of a larger fluid flow, as compared to the one in the preceding example, by

increasing the fluid passage section due to the use of several rotors of same diameter, namely: two extreme rotors with one front face each, provided with tilting blades 12, of which one, either the upper rotor B or the lower rotor C is mounted on one of the machine shafts and the other, a ring rotor E without supporting elements on machine shaft, and a number of disk F or ring G intermediate rotors with two front faces each, provided with tilting blades 12 on both faces, the blades on one face being mirror like arranged to those on the other face, their size and number being the same for the front faces of the rotors on each stage while they can vary from one stage to the other.

The tilting blades 12 of each rotor are arranged in such a manner as the neighbouring rotors move to opposite direction from one another, the distance between the rotors front faces representing the height of the fluid flowing channel a at each machine stage.

All rotors moving to one sense are rigidly coupled between them, making one package of rotors with the tilting blades 12 axes arranged on the same vertical planes so as inside the machine be two packages of rotors, moving to opposite senses from one another, each package being coupled to one of the two machine shafts, to which they convey the motion received from the working fluid.

The upper B and lower C rotors are similarly from constructional point of view to those given in the preceding example whereas the ring rotor E is different from constructional point of view only through the absence of the coupling elements on machine shaft-disk 8 or 9 respectively and the hub 10 or 11 respectively - and can be mounted, both in upper and lower position, depending on the constructional variant chosen.

The intermediate disk like rotor F consists of a flat ring plane 6 fixed, by means of disk 8, 9 respectively, onto hub 10, 11 respectively through which it conveys the motion to one of the two machine shafts: upper and lower ones, respectively.

The ring plane 6 has two parallel front faces provided with shaped grooves b made according to one of the variants described in the aforesaid example, each groove being provided with in line orifices p and r for the hinged fastening of blade 12 onto the rotor. The shaped grooves b on the front face of plane 6 are symmetrically - mirror like - arranged as compared to those on the other front face, all being arranged in such a manner as to secure the rotor, by the position of the tilting blade on respective surface, a rotation movement to the opposite sense of the two neighbouring rotors.

According to a constructional variant, the intermediate rotor F is made of a ring 16, concentrically attached to frame 7, interdependent to disks 8, 9 and hubs 10, 11 respectively, through the rods 17, eventually arranged radial and which can also serve as position limiters for blades 12 in passive position, shaped to this end according to blades profile. Both the ring 16 and the frame 7 are provided with coaxial orifices p and r respectively in order to mount the tilting blades pairs.

In another constructional variant, in order to reduce rotor F thickness, the rotor has the blades 12, located in opposite positions on the two front faces, installed either on a single shaft or on coaxial shafts, the rotor being in this case provided with one row of orifices p and r. The two tilting blades 12, each have the hub made of one or several elements f fixed on panel c edge and arranged along its entire length, alternatively with the ones making the hub of the pair blade thus making together a "hinge" type articulation, either loose on the shaft 15 if it is connected in the corresponding orifices p and r of the rotor, or connected by their hubs f, by known means, not shown on drawing, one directly on shaft 15 while the other - loose against shaft 15 - fixed on a tubular shaft 78, in line with it, in this latter case, the corresponding p and r orifices of the rotor having installed the bearings 13 and 14 respectively, while the two shafts 15 and 78 are meant for mounting the blades driving mechanism. Under this variant, in the case of a rotor made up of a ring panel 6, the seat shaped for the

increasing the fluid passage section due to the use of several rotors of same diameter, namely: two extreme rotors with one front face each, provided with tilting blades 12, of which one, either the upper rotor B or the lower rotor C is mounted on one of the machine shafts and the other, a ring rotor E without supporting elements on machine shaft, and a number of disk F or ring G intermediate rotors with two front faces each, provided with tilting blades 12 on both faces, the blades on one face being mirror like arranged to those on the other face, their size and number being the same for the front faces of the rotors on each stage while they can vary from one stage to the other.

The tilting blades 12 of each rotor are arranged in such a manner as the neighbouring rotors move to opposite direction from one another, the distance between the rotors front faces representing the height of the fluid flowing channel a at each machine stage.

All rotors moving to one sense are rigidly coupled between them, making one package of rotors with the tilting blades 12 axes arranged on the same vertical planes so as inside the machine be two packages of rotors, moving to opposite senses from one another, each package being coupled to one of the two machine shafts, to which they convey the motion received from the working fluid.

The upper B and lower C rotors are similarly from constructional point of view to those given in the preceding example whereas the ring rotor E is different from constructional point of view only through the absence of the coupling elements on machine shaft-disk 8 or 9 respectively and the hub 10 or 11 respectively - and can be mounted, both in upper and lower position, depending on the constructional variant chosen.

The intermediate disk like rotor F consists of a flat ring plane 6 fixed, by means of disk 8, 9 respectively, onto hub 10, 11 respectively through which it conveys the motion to one of the two machine shafts: upper and lower ones, respectively.

The ring plane 6 has two parallel front faces provided with shaped grooves b made according to one of the variants described in the aforesaid example, each groove being provided with in line orifices p and r for the hinged fastening of blade 12 onto the rotor. The shaped grooves b on the front face of plane 6 are symmetrically - mirror like - arranged as compared to those on the other front face, all being arranged in such a manner as to secure the rotor, by the position of the tilting blade on respective surface, a rotation movement to the opposite sense of the two neighbouring rotors.

According to a constructional variant, the intermediate rotor F is made of a ring 16, concentrically attached to frame 7, interdependent to disks 8, 9 and hubs 10, 11 respectively, through the rods 17, eventually arranged radial and which can also serve as position limiters for blades 12 in passive position, shaped to this end according to blades profile. Both the ring 16 and the frame 7 are provided with coaxial orifices p and r respectively in order to mount the tilting blades pairs.

In another constructional variant, in order to reduce rotor F thickness, the rotor has the blades 12, located in opposite positions on the two front faces, installed either on a single shaft or on coaxial shafts, the rotor being in this case provided with one row of orifices p and r. The two tilting blades 12, each have the hub made of one or several elements f fixed on panel c edge and arranged along its entire length, alternatively with the ones making the hub of the pair blade thus making together a "hinge" type articulation, either loose on the shaft 15 if it is connected in the corresponding orifices p and r of the rotor, or connected by their hubs f, by known means, not shown on drawing, one directly on shaft 15 while the other - loose against shaft 15 - fixed on a tubular shaft 78, in line with it, in this latter case, the corresponding p and r orifices of the rotor having installed the bearings 13 and 14 respectively, while the two shafts 15 and 78 are meant for mounting the blades driving mechanism. Under this variant, in the case of a rotor made up of a ring panel 6, the seat shaped for the

installation of the in-line tilting blades pairs with coaxial hubs, results from crossing the opposite shaped grooves b on the respective front faces of the panel and is symmetrical to a plane containing the rotation axes of the rotor blades, made up of the plane surfaces m, the shaped surfaces n as well as the ending surfaces of the two grooves.

The intermediate rotor G, in the form of a ring, similar from constructional point of view to the above described intermediate rotor F, is devoid of the coupling elements to one of the machine shafts - disks 8, 9 respectively and hubs 10, 11 respectively - being provided on both front faces with tilting blades 12 arranged in such a manner as to secure a rotation movement to the opposite sense of its neighbouring rotors.

The machine can be built in several constructional variants, having an even or uneven number of stages.

In a constructional variant, in the general case of a machine with an even number of stages and uneven number of rotors consequently, the two packages of rotors consist of:

- one package H made up of extreme rotors, the upper rotor B and the ring rotor E loose against the machine shaft, with tilting blades on one face, among which it can be found, in the case of the machines with a number of stages > 2,one or several intermediate rotors G_1, G_2 with tilting blades on both faces, all the rotors of the package being rigidly fixed to one another by means of longitudinal tie-bars 76, equally spaced, along parallel or concurrent directions, on the outer outline of the respective rotors and provided with stiffening plates 77 and fastening elements - bolts and nuts - known in themselves, not shown on the drawing. The whole package of rotors is coupled, by means of hub 10 belonging to the rotor B, to one of the machine shafts, either to the outlet one, at the upper side of machine 52 or 67, or to the central shaft 66, when it gets out at the machine lower side.

In a constructional variant, the rotors package H is provided at its upper side, with a ring rotor E, loose against the machine shaft, whereas at its lower side it is provided with an extreme rotor C, by whose hub 11 the whole package of rotors is coupled to a shaft, either to the outlet one at the machine lower side 53 or 67, or to the central shaft 66, when it gets out at the machine upper side; in the particular case of a two staged machine, the rotors package H consists only of the two extreme rotors, without any intermediate rotor G:

- a package I, consisting of one or several intermediate rotors F_1, F_2...... with tilting blades on both faces, each rotor being placed between two neighbouring rotors, belonging to the other package of rotors H and directly coupled, by its hub, to the other shaft, according to the constructional variant chosen for the rotors package H.

In a constructional variant, the rotors package I consists of one intermediate rotor in the form of a disk F_1, located in the machine in the vicinity of the extreme rotor B or C of the rotors package H, and a number of intermediate rotors in the form of a ring G, all the rotors of the package being rigidly fixed to one another by means of longitudinal tie-bars 76 and of fastening plates 77, equally spaced on the inner outline of the frame 7 of each rotor, inside the drums D the whole package of rotors being coupled to the machine shaft by the hub of the rotor in the form of a disk F_1, the form of the ring rotors G permitting the reduction of the gap inside the machine drums by shaping accordingly the lid 4 or 5 placed in the vicinity of the extreme rotor E of the rotors package H.

In another constructional variant, in the general case of a machine with an uneven number of stages > 1 - therefore, with an even number of rotors - the two packages of rotors are made up of the following:

- a J package consisting of the upper rotor B, with tilting blades on one face and several intermediate rotors as rings G_1, G_2, having tilting blades on both faces, fastened to one another by means of tie-bars 76 and of fastening plates 77, the whole package being coupled by hub 10 onto the upper rotor B, to one of the machine

shafts, either the outlet one at the upper side of the machine, **52** or **67**, or to the central shaft **66**, when it gets out of the machine at its lower side.

In another constructional variant, the rotors package **J** is made up of a number of intermediate rotors G_1, G_2.... and the lower rotor **C**, with tilting blades on one face, by whose hub **11**, the whole package is coupled to one machine shaft: either to the outlet one, at the lower side of machine **53** or **67** or to the central shaft **66** when it gets out at the upper side of machine.

- a package **K** consisting of the other extreme rotor with tilting blades on one face, the upper rotor **B** and the lower rotor **C** respectively, and one or several intermediate rotors F_1, F_2.... with tilting blades on both faces, intercalated between the rotors of the other package and directly coupled by its hub, each, to the other shaft of the machine, according to the variant chosen for the rotors package **J**.

In a constructional variant, the rotors package **K** consists of an intermediate rotor, as a disk F_1 located in the vicinity of the extreme rotor **B** or **C** of the rotors package **J**, several intermediate rotors in the form of a ring **G** and an extreme annular rotor **E**, all the package rotors being rigidly fixed among them by means of longitudinal tie-bars **76** and of fastening plates **77**, equally spaced on the inner outline of the frame **7** of each rotor, inside the drum **D**, the whole rotors package being coupled to the machine shaft by the hub of the rotor in the form of a disk F_1 whereas the lid **4** or **5** placed in the vicinity of rotor **E** of the package is duly shaped so as to reduce the gap created inside the drums **D**.

In the particular case of a one staged machine, the two rotors packages **J** and **K** are made up of one rotor each, either **B** or **C**, the constructional type being similar to that described under example 1.

Each machine stage, within the space formed between the front faces of two neighbouring rotors, is provided with one drum D_1, D_2... similar to that described in the previous example, equipped on its body **45** with the deflector **46** and the rib **47**, diametrically opposed, whose extreme edge do not exceed the outline of said rotors.

All the drums D_1, D_2... are arranged in the same position, with deflector **46** located in the symmetry plane of inlet nozzle and coupled to one another, making a package to be fixed onto one of the casing **A** lid of the machine. Fastening of the adjacent drums D_1, D_2... to one another or of the whole package of drums to the casing lid is achieved either through the rotor outside, in case they are located on both sides of rotor directly coupled onto one of the machine shafts, or through rotor inside, in case they are located on both sides of a rotor coupled to the others at the outside, by tie-bars **76**.

Thus, the drums **D** located on both sides of an **F** type rotor, directly coupled by its hub onto the machine shaft, are located to one another by rotor outside, using the fastening plates **48** and **49** respectively, in interdependence with deflector **46** and the rib **47** respectively, between which spacers **79** are mounted by means of fastening parts which are not shown on the drawing, all elements being known in themselves. Likewise, the whole package of drums is fixed on one of casing **A** lids by the outside of a rotor, directly coupled to the machine shaft, by means of shorter spacers **50**, located between the fastening plates **48** and **49** of the drum and the associated lid.

The shape and size of the fastening plates **48** and **49** as well as the location of spacers **79**, **50** respectively, are selected in such a manner as to permit both the movement of the rotors directly coupled to the machine shaft and the movement of the rotors belonging to the other package, coupled at the outside, by means of tie-bars **76** while the clearance between the fixed parts and the moving ones should be minimum so as to diminish the hydraulic losses.

The drums **D** located on both sides of a rotor **G** coupled to the other rotors of the package it belongs to, at the outside, by means of tie-bars **76**, are fixed among them by means of fastening rings **80** located inside the body **45** of the drum, in interdependence with it, and by means of spacers **79** located between said rings, all elements being known in themselves. Likewise, the whole package of drums is fixed on one of casing **A** lids above a rotor coupled at the outside to the package of respective rotors by means of shorter spacers **50**, located between the ring **80** and the respective lid.

The opposite tilting blades **12** located on the front faces of **F** and **G** type rotors having parallel rotation axes arranged in the same vertical plane can be coupled two by two by means of geared segments **81**, permanently engaged, mounted on the ends of the two shafts **15** of the blades, in such a manner as, when driving one of them - further on called leading blade - the other blade - further on called led blade - should make an identical movement to the opposite direction, thus achieving the synchronisation of the movement of the blades located in the same vertical plane.

In the variant of **F** and **G** type rotors, having opposite tilting blades **12**, on the two front faces mounted on in - line shafts, the synchronisation of the tilting movement of the two blades can be achieved by mounting on the two shafts **15**, **78** some cone pinions **82** and **83** respectively, permanently engaged with a pinion **84** which, due to the fact it rotates freely on an axle **85** fixed on the rotor, has the role of reverting the moving direction transmitted from one pinion to the other, all elements being known in themselves.

The blades driving mechanism **12**, similar to the one described in the previous example is installed at all machine stages on the shaft of each blade belonging to the extreme rotors **B**, **C**, **E** and on the shaft of leading blade belonging to rotors **F**, **G** having the blades on both front faces. The cams pairs **24**, **25** or **34**, **35** and **41**, **42** respectively of the driving mechanism, made according to one of the variants described in the previous example, are mounted at each stage of the machine onto the associated drum **D** so that to assure the simultaneous tilting of the blades located on the same vertical generatrix of the respective package of rotors.

In another constructional variant, the machine is provided with one pair of cams **24**, **25** or **34**, **35** and **41**, **42** respectively and the adequate driving mechanisms, according to those previously described, located only at the level of leading blades, either at the first or the last stage of machine, the movement being simultaneously transmitted from each of them to all the leading blades on the same vertical, on the other rotors making the package of respective rotors by synchronisation mechanisms consisting of elements known in themselves.

Thus, in the case of package **H**, **J** of rotors fixed between them at the outside by tie-bars **76** and plates **77**, all the leading blades are provided with one pinion **86** fastened on shaft **15** end, outside the rotor, all the pinions **86** on the same vertical being engaged by means of a common rack **87** located in a casing **88**, fixed at the periphery of the rotors making the said package, in such a manner as the motion transmitted from the blade of the first rotor, or, in a constructional variant, of the last rotor, is simultaneously transmitted, by rack **87** and by gear segments **81** or cone gears **82**, **83** and pinion **84** to all the blades on the same generatrix of the rotors package.

In the case of the other package **I**, **K**, all the leading blades of the lower and upper levels respectively, of the rotors package are provided with a driving element, a lever **21**, a pinion **26**, or a cone pinion **29** engaged with a cone gear **30**, similarly to the driving elements of the leading blades of the first and last stage respectively, mounted on the shaft **15** end, inside the rotor. For the simultaneous motion transmission to all the stages of the rotors package, the driving elements of the leading blades at the first stage or the last one respectively, are coupled to those of the blades located on the same vertical, at the other stages, by means of linking elements: a joint stem **89** hinged to levers **21** in order to make deforming parallelograms, or a joint vertical rack **90**,

simultaneously engaged with the pinions 26 from all stages, provided at its upper or lower end with a shaft **22** and a roller **23** in contact to the surfaces of driving mechanism cam, or a joint shaft **91** on which are fixed all the cone gears **30** of the rotors package installed on the same vertical, the rotors disks making the package being provided with orifices m' and c' permitting the installation of said linking elements.

In the case of rotors F and G having opposite blades on the two faces, in line and loosely mounted on the shaft, the driving mechanism of each blade consists of cams **41** and **42** attached onto the drums **D** of each machine stage and of twisted springs **44** located in the orifices s' drilled in the hubs f of each blade, as described in the previous example. The orifices s' are drilled in the extreme hubs of the two blades, in such a manner as each blade be driven by spring **44** installed in the associated orifice s' and tensioned between its gap t' and a fixed point on rotor, that is orifice k' drilled in the frame 7 for one of the blades and orifice z' drilled either in the outer wall of groove b or in the ring wall **16** for the other blade.

In a constructional variant, orifices s' are drilled in two neighbouring hubs located face to face so that the two blades be simultaneously driven by one spring **44** installed in the seating formed of the two orifices s' and tensioned between their gaps t'.

EXAMPLE 3

The hydraulic or pneumatic machine with tilting blades, according to the invention, for working fluids under static pressure.

In view of adjusting the machine to run as a hydraulic or pneumatic motor using a working fluid under static pressure, in the circular space between the cylindrical shell **1** of stator **A** and the cylindrical body **45** of drum **D**, interdependent to it, is fixed a cylindrical ring **92** with the height corresponding to the distance between the front surfaces of rotors **B**, **C**, having on each front face of it a channel a'' of variable depth, for the action of the tilting blades **12** of the rotor close to said surface, the two channels connecting the fluid inlet and outlet nozzle, diametrically opposed, each having an initial zone b'', with a depth increasing to the rotation sense of said rotor, on the angular sector γ_1 specific to blade transition from passive to active position, a middle zone c'' open to the other rotor, with constant depth, equal to the height of the cylindrical ring **92**, on the angular sector γ_2, specific to keeping the blade in active position on rotor, and a terminal zone d'', with decreasing depth, on angular sector γ_3, specific to blade transition from active to passive position.

The bottom of channel a'' in the zones with increasing depth b'' and decreasing depth d'' consists of some shaped surfaces e'' and f'' respectively, similar to the surfaces generated by the edge of blade panel parallel to its rotation axis, at the movement of said tilting blade through the channel, on the angular sector γ_1 and γ_3 respectively, whereas the lateral walls of the channel consist of an external shaped surface g'' and an internal shaped one h'', similar to the surfaces generated by the other edges of the blade panel, in such a manner as the interspace between the shaped surfaces of the channel and the corresponding blade edges should have minimum values during its whole evolution in the said channel.

The two channels a'' can be served by separate inlet **2** - outlet **3** nozzles or by jointly shared nozzles.

The connection between the inlet nozzle **2** on shell **1** of stator **A** and each of the two channels a'' is achieved either separately, by a radial channel i'' in the cylindrical ring **92**, provided with a branch j'' communicating to a slot k'' drilled in the shaped surface e'' of the initial zone b'' of the channel, or by a joint radial channel i'', connected to both branches j''. According to other constructional variants, the connection between the radial channel i'' and each channel with variable depth a'' is achieved either directly by some slots

l'' made in one or both lateral faces - the outer one g'' and the inner one h'' - on one portion or along the entire initial zone b'' of said channel, or by a groove m'' with variable or constant depth, executed on the bottom surface e'' on one portion or along the entire initial zone b'', communicating to the radial channel i'' by its branch n''.

The connection between each channel with variable depth a'' and the outlet nozzle 3 is achieved either by slots o'' drilled on one or both lateral surfaces - outer g'' and inner h'' one, over the entire length of the terminal zone d'' of the channel or by a groove p'' with variable or constant depth, executed along the bottom surface f'' of terminal zone d'', connected to a slot q'' located on an extension of said channel, the two slots q'' being able to merge so that the channels with variable depth a'' on the two front faces communicate to each other, the cylindrical ring 92 being provided with one or several radial channels r'' making the connection between the said slots o'', q'' and the outlet nozzle 3.

According to a constructional variant, the distance between the front faces of the two rotors **B**, **C** can be increased, without modifying the tilting blades dimensions 12, by adequately increasing the heights of the cylindrical ring 92 and of drum **D**, the channels a'' having the depth correlated to the height of the blade in active position on the associated rotor and being closed all along their entire length.

In another variant, if the height of cylindrical ring 92 exceeds the sum of the depths of the two channels a'' the length of their shaped zone can be increased so that for each channel:

$$\gamma_1 + \gamma_2 + \gamma_3 > 180°,$$

the plan projections of the two channels overlap over a certain portion while the orientation of the driving mechanism cam of the tilting blades of each rotor **B** or **C** corresponds to the plane position of the respective channel a''.

In other constructional variants, either the terminal zone d'' of channel a'', closed or open, has a constant depth along its whole length, equal to that of the middle zone c'', being eventually devoid of the discharge groove p'' and communicating directly to slot q'', located on an extension of said channel, connected to outlet nozzle 3, or the channel a'' is devoid of the middle zone c'' with constant depth, the initial zone b'' being directly connected to the terminal zone d''.

Thus, inside each channel a'' of the cylindrical ring 92, between the adjacent tilting blades 12 of each rotor, are formed some mobile compartments, demarcated from the active and passive surfaces of said blades, the rotor front face and the faces of channel a'' over the portion covered between the two blades, the volume of said compartments being variable due to the blades motion along the channel, on its variable depth zones - the initial b'' and eventually the terminal zones d'' - and constant on its middle zone c''.

In view of diminishing the losses due to leaks, the front surfaces of the cylindrical ring 92 can be provided with baffles or sealing labyrinths, known in themselves, not shown on the drawing, arranged on one or both edges of the channel a'', concentrically with the channel and, eventually, at one or both ends of the said channel, to a radial direction.

In the functional variant as pneumatic motor, the working fluid is either gas or pressure steam coming from an external storage tank, known in itself, not shown on the drawing, or gases coming from combustion fuel into a combustion chamber 93 outside the motor, known in itself, or into a combustion chamber s'' located inside the cylindrical ring 92, both equipped with feeding devices for the formation of fuel mixture and its ignition, all known in themselves, not shown on drawing and connected by one or several radial channels i'' to the channels with variable depth a''.

Along the zone with increasing depth b'' of channel a'', the pressure in each moving compartment between two successive blades, varies with the increase of its volume, from a maximum feed value, in the compartments directly connected to the fluid inlet nozzle, or by slot k'' or slots l'' or channel m'' executed on part of the said zone, to a minimum value, at the end of the initial zone b'' and on the middle zone c'' with constant volume compartments, while subsequently, on the terminal zone d'', due to the direct connection of each compartment to the outlet nozzle 3 either through slots o'' or through the grooves p'', slots q'' and channels r'', the pressure decreases to the value of the motor outlet pressure.

Each compartment located on the initial zone b'' of the channel, containing the working fluid under a certain pressure, borders, any time, upstream on a compartment with lower volume and higher pressure and downstream, on a compartment with higher volume and lower pressure so that the total pressure drop over the entire initial zone b'' occurs in a number of pressure stages equal to the number of compartments located at a certain time in the said zone of the channel, the pressure drops from one compartment to the other through the interstices between the tilting blades and the channel walls they move in, being diminished due to the low pressure difference existing between the said compartments.

The driving forces causing the rotor movement manifest themselves in all the compartments located in the initial zone b'' of the channel acting upon the active surfaces of said blades and having values proportional to the fluid pressure in the compartment and to the depth difference of the channel, measured at the top ends of the two blades delimiting the compartment, the torsion moment of the rotor shaft being the sum of the moments given by all said forces.

In other variants, as hydraulic motor, feeding is done by a pressure fluid, either through the slots l'' or the groove m'' executed along the entire length of the initial zone b'' of the channel a'', the liquid pressure being almost constant in all compartments with growing volume. The liquid discharge from the motor starts at the same time with the motion of the tilting blade on the terminal zone d'' of the channel, the said compartment being connected either by slot o'' or by groove p'' on this zone to the outlet nozzle 3. The driving force acts on the tilting blades 12 located in the middle zone c'' of channel a'' due to the liquid pressure difference in its two neighbouring zones b'', d''.

In a constructional variant, driving each rotor by a driving moment applied on its shaft in such a manner as the tilting blades 12 should travel through the channels with variable section a'' to opposite sense - the vertex of the angle between the blade and the front face of the rotor oriented to the opposite sense of rotation - the previously described machine runs as a hydraulic pump or compressor. The working fluid flows in channel a'' to the sense the rotor blades move, being sucked in the terminal zone of the channel d'' either by slot o'' or by groove p'' and slot q'', connected to nozzle 3 which became a suction nozzle due to the volume increase in the mobile compartments formed on the rotor when travelling through this zone and discharged by nozzle 2 which became a discharge nozzle, at a pressure higher than the suction one, after being previously compressed eventually - in case of operation with compressible fluids - due to the volume decrease of the said compartment when travelling through the initial zone b'' of the channel.

In other constructional variants, the machine rotors have one or several concentric rows of tilting blades 12 which may differ among them, from one row to the other or from one rotor to the other, in terms of shape, dimensions and position on rotor, each row of blades being provided with a driving mechanism of its own, according to previous examples. On the front surface of the cylindrical ring 92, close to the front surface of the respective rotor, there is a corresponding number of concentric channels a''_1, a''_2...... with variable depth, which can be independent - with inlet and outlet nozzles of their own - or coupled between them, on the same or

different faces, either in parallel - with joint inlet and outlet nozzles for several channels - or in series, one in continuation to the other, so that the fluid flows the whole way from inlet to outlet, through one or several channels, to the moving direction of the tilting blades **12**, the plane orientation of the cams driving mechanisms of each row of blade being correlated to that of channel a'' wherein the said blades act while the two outlet shafts of the machine, coupled to rotors **B**, **C** can rotate to the same or to opposite senses.

Each channel a''_1, a''_2 on the face of the cylindrical ring **92** can be framed by baffles or sealing labyrinths, elements known in themselves, not shown on drawing, in order to diminish the pressure losses to the outside or to the neighbouring channels.

Several constructional variants are possible due to the position of the tilting blades **12** on the rotor faces, as defined by the orientation of the angle vertex α formed between the said surface and the blades, against the rotor moving sense, position which can be the same for all rows or may differ from one row to other.

Thus, locating the tilting blades **12** on several concentric rows, id est two, in the same position, with the angle vertex α to the rotation sense of the rotor, and the corresponding concentric channels a''_1 and a''_2 respectively, one in the continuation to the other, coupled in series by an intermediate shaped channel t''_{1-2}, connecting the slot o''_1 or q''_1 of the terminal zone d''_1 of the first channel a''_1 and the slots k''_2 or l''_2 or n''_2 of the initial zone b''_2 of the other channel a''_2, the pressure gas gets in by the motor inlet nozzle **2** into the initial zone b''_1 of the first channel a''_1 passes successively through the two channels - acting on the tilting blades of the two rows, found in active position due to their own driving mechanisms, duly oriented - and goes out of the motor by the discharge nozzle **3** connected to the terminal zone d''_2 of the other channel. By choosing the due dimensions of the channels a''_1 and a''_2 and the right number of tilting blades **12** on each row, a continuous volume increase may be secured for the compartment located between two successive blades and consequently the prolonged expansion of the working fluid the whole way through, from the circuit inlet to outlet, causing the occurrence of some moving forces which act over the blades located in the initial zone b''_1 and b''_2 of both channels.

According to one constructional variant, by acting each rotor by a driving moment applied on its shaft so that the tilting blades run through channels a''_1 and a''_2, coupled in series, to opposite sense, having the angle vertex α in the opposite sense of the rotor movement, the working fluid is sucked by the nozzle **3** of the terminal zone d''_2 of channel a''_2 which it is connected to, runs through the two channels, driven by the tilting blades **12**, being compressed, due to the continuous volume decrease of each compartment in the said channels and gets out by the nozzle **2** connected to the initial zone b''_1 of the other channel a''_1, the machine running as a compressor.

In other constructional variants, the cylindrical ring **92** surface may have simultaneously independent channels a'' as well as channels connected in parallel or in series, making separate circuits, each circuit running according to the orientation of the respective tilting blades against the rotor, either as an engine or a pump, with the same fluid or different ones. Thus, according to one constructional variant, a pumping circuit achieved with one or several channels a'' supplies air or a fuel mixture under pressure to an outside combustion chamber **93** or a combustion chamber s'' located in the cylindrical ring **92**, whence, the gases resulted from combustion circulate through other channels a'', setting into motion the respective tilting blades of the rotor, part of the generated energy being used for the feed mixture compression.

In other constructional variants, the hydraulic machine is multistage, according to example two, the rotors with the same diameter or those with different diameters having the tilting blades arranged on one or

several concentric rows, the drum **D** of each stage having fixed a cylindrical ring **92** provided with channels a'', with corresponding variable section, which can be coupled between them on each stage, as previously described, or between stages, in such a manner as to make inside the machine, either one circuit running as an engine or a pump (compressor), or several circuits of which some are running as an engine while the other are running as a pump (compressor), using one or several working fluids.

The cylindrical rings **92** located on both sides of the rotor faces are fixed in interdependence to the respective drums **D** either by means of fastening ribs **48** and rings **80** respectively as well as of some fastening elements - such as bolts, nuts, etc. - or by some space rings **94** located between the two neighbouring cylindrical rings **92**, concentrically to them - either outside the disk rotors **F** or inside the ring rotors **G** - holding being achieved by bolts and nuts, known in themselves, not shown on the drawing - the space rings **94** can be provided with channels u'' and v'' connected to the inlet channels i'' and the outlet channels r'' executed into the neighbouring cylindrical rings **92**.

The tilting blades on each front face of the intermediate rotors **F**, **G** are driven either by a common mechanism, according to previous examples or by a mechanism of their own, dismissing eventually the permanent coupling of the tilting blades located on the opposite faces of a rotor, by geared segments **81**, the plane orientation of the cams pairs of the independent driving mechanism of each stage can be different in this variant, from one stage to another, according to the orientation of the channels with variable section a'' wherein the tilting blades move on the respective stage and row.

In the case of the fluid circuits extended over several stages of the machine, the coupling of the channels a'' located on different stages is done by some pipes **95**, known in themselves, which make the connection between the radial inlet channels i'' and respectively the radial outlet channels r'' of channels a'' from one stage to those of the next stage, according to the chosen connections plan.

In the case when, in order to make a circuit by coupling the channels from one stage to those of the other stage or to the inlet or outlet nozzles of the machine, it is necessary to cross one or several intermediate stages, their cylindrical rings **92** are provided with radial channels w'', coupled to the associated connecting pipes **95**.

The connecting pipes **95** are located either outside the cylindrical rings **92** or inside the drums **D**, similarly to the fastening elements of the neighbouring drums **D** as they frame a disk rotor **F** or ring rotor **G** respectively, the position of inlet radial channels i'' and outlet channels r'' respectively - to the outside or the inside of the cylindrical ring **92** - being chosen so as to suit the position of the respective pipes. The machine inlet - outlet nozzles respectively and the connecting pipes **95** coupled to them are located on the circular ring **92** being part of the drum **D** which is directly fitted on the machine casing, their number corresponding to the number of the existing fluids circuits and to their way of coupling.

In other constructional variant, the connection between the channels a'' of the various stages can be achieved by the channels u'' and v'' existing in the spacing rings **94**.

In other constructional variants, in order to reduce the axial forces resulted in the shafts bearings, the machine has only rotors with tilting blades on both faces, either two disk rotors **F**, each coupled to one of the outlet shafts, or a package **I** made up of disk rotors **F**, each coupled directly to one of the machine shafts and a package **J** made up of ring rotors **G** and an extreme rotor **B** or **C**, devoid of tilting blades on its front face, used only for coupling the whole package to the other machine shaft by its disk **8** or **9** respectively, extended to the rotor periphery and its hub **10** or **11** respectively, belonging to it. The cylindrical rings **92** fitted onto the drums **D** of each stage have channels a'' with variable depth on one or both front faces as they occupy inside the machine

an extreme position, bordering one surface of rotor **F**, **G** or an intermediate position, between the surfaces provided with tilting blades of two neighbouring rotors **F**, **G**.

In the particular case the tilting blades on the two front faces of each rotor are identical, as shape and arrangement, and the fluids pressures in the corresponding channels a'' on the cylindrical rings **92** are equal, the resulting axial force acting on the rotor is null.

In other constructional variants, the hydraulic machine can have only one upper outlet shaft **52** or a lower one **53**.

Thus, in a constructional variant, the extreme rotors **B** and **C** are fastened by their hubs on the same outlet shaft of the machine, the orientation of the tilting blades on the front faces of the rotors and that of channels a'' on the front faces of the cylindrical ring **92** being selected so as to make both rotors move to the same sense.

In other constructional variant, the hydraulic machine has one extreme rotor **B** or **C**, provided with one or several rows of tilting blades **12**, the cylindrical ring **92** - having, accordingly, one or several channels a'' on the surface adjacent to the rotor - being fitted on the lid **5** or **4** opposite to the respective rotor.

In another constructional variant, in order to reduce the resulting axial force acting on the shaft, the hydraulic machine has one rotor with tilting blades **12** on both faces, similarly to the disk type intermediate rotor **F**, previously described, installed on its shaft **52** or **53** and two cylindrical rings **92** fitted on the lids **4** and **5** of casing **A**, on both sides of the rotor, provided on their front faces with the channels a'' having variable depth, corresponding to the rotor tilting blades, separated or coupled to one another, in series or in parallel.

In a variant, the hydraulic machine has several disk rotors **F** with tilting blades **12** on both faces, fastened on a joint shaft **52** or **53**, spaced from one another in the form of a package of rotors **I** and a corresponding number of cylindrical rings **92** with channels a'', having the shape and dimensions adequate to the blades of the associated rotor, located either on one front face - in the case of the those located at the ends of the rotors package and fitted on upper **4** or lower **5** lids - or on both front faces - in the case of those located between two neighbouring rotors, eventually fixed on the cylindrical shell **1** of stator **A**.

In other constructional variants, the machine has one or several rotors with tilting blades **12** on both faces, similarly to the ring type intermediate rotor **G**, previously described, and an extreme rotor **B** or **C**, devoid of tilting blades on its front face, all making a package of rotors **J** installed on the outlet shaft **52** or **53** by the disk **8** or **9** extended to the periphery of the extreme rotor and its hub **10** or **11**.

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